LOCAL DECOMPOSITION OF ROCK BY THE CORROSIVE ACTION OF PRE-GLACIAL PEAT-BOGS

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While the layer of decayed rock which once overlay the region around New York City has been generally planed off by the continental glacier, certain small isolated spots have been noted from time to time in which masses of rotten schist still remain. Their decay is commonly attributed to weathering action, and their escape from the glacial scour at such points, to their probable protection by projecting eminences of rock under whose lee they are supposed to lie.

Excavation in schist.—An unusually large occurrence of this kind has been recently exposed in an excavation for a cellar on the east side of the junction of Southern Boulevard and Westchester Avenue, Borough of the Bronx, New York City, whose general form and dimensions[1] are shown in Fig. 1.

The gneissic schists here present the foliation with usual high angle, 70° to 90°; strike N. 23° E. and S. 23° W. A small anticlinal fold crosses the strata, as shown in the diagram (Fig. 1) whose axis runs N. 52° E. and S. 52° W. A small overthrow is shown in its cross-section at the northern end, and at its southern end it pitches to the southwest at an angle of about 30°. The rock consists chiefly of a fine granular aggregate of quartz, with much biotite in minute black scales, and more or less disseminated white feldspar. Throughout the western half of the excavation, however, many thin seams of pegmatitic gneiss and of gray quartz are intercalated, up to nine inches in thickness.

Pegmatite dike.—A pegmatite dike, about five feet in width, nearly vertical, also cuts obliquely through the schists, with a course of N. 30° E. and S. 30° W. At many points, small projections or apophyses branch out into the schist along its course and are,

[1] We wish to express our indebtedness for these data to Mr. C. S. Shumway, superintendent of the Construction Department of the American Real Estate Co.

apparently, connected with some of the pegmatitic seams intercalated in the schist. The position of the dike, on the west side of the overthrow in the anticline at the north end, suggests that it has there acted as an obstacle against the northwestward thrust of the beds and so produced the westward distortion of the upper side of the fold. The pegmatite itself is an aggregate of grayish quartz, white feldspar, and very little mica, of the rather uniform medium texture usual in the dikes of the Bronx region, with grains rarely exceeding two or three inches.

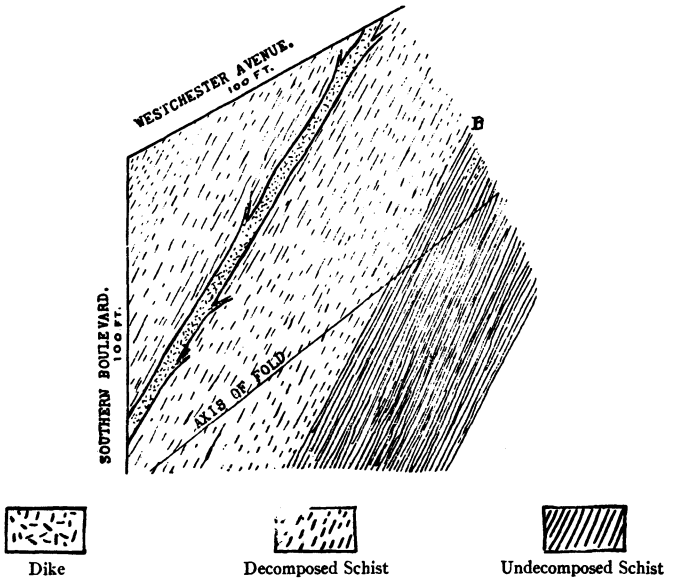

FIG. 1.—Relative positions of decomposed schist, undecomposed schist, and pegmatite dike.

Decay of schist.—In the eastern part of the excavation, the rock was hard and sound, and needed to be blasted for removal. In the western, the schist was thoroughly decomposed throughout to an undetermined depth, so soft that it was easily removed with pick and shovel, bluish to purple gray in color, and in texture passing from a gritty aggregate almost to a clay; the latter corresponded closely to the glacial clays of similar color commonly found about the city. The two tracts, fresh and decayed, were separated by an exceedingly sharp contact (the line A–B in the diagram), so that,

in the cross-section at the north end (at the point B), the hand placed across this line would rest on the left upon the decomposed schist, easily dislodged by the touch of a finger, and on the right upon the hard fresh rock. This contact is shown in Fig. 2, with the decayed schist on the left, and on the right the same rock in rugged, hard condition. The trend of this sharp division line was N. 28° E. and S. 28° W., approximately parallel to the course of the dike. However, in the cross-section, a few seams of decayed rock were noticed to the east of this line, descending a yard or more into the solid schist. The same section showed that the upper eroded surface of the schist descended from a height of fourteen feet at the point B along the northeast wall, to a height of seven and one-half feet, in a distance of fifty-four feet to the corner on Westchester Avenue.

FIG. 2.—Contact of decomposed and undecomposed schist.

Decay of pegmatite.—A similar decay has affected the pegmatite, much of whose feldspar has passed into a white kaolinic clay, so that this rock also was easily removed by means of the pick. Although it is even now much more tough and solid than the surrounding schist, it appears to have been planed off by the ice at about the same level, as shown near the bottom of the cross-section (Fig. 3) where the north end of the dike strikes the wall at Westchester Avenue. Above it lies a layer of till, and then a slab of granitic gneiss. It should be also noted that the decay above described is entirely exceptional in this region. For example, in another excavation in the schist, a few hundred feet to the north, the same schist was found practically undecomposed and sound. So also as to the numerous other pegmatite dikes in the Bronx, all we have observed are solid and show almost no decay.

Glacial deposits.—The layer of glacial deposits, which overlies the schist at this locality, as shown in the following generalized cross-section along Westchester Avenue (Fig. 4), about fifteen feet from the street level to the greatest depth in the excavation, is yet to be considered.

	Feet
Fawn-colored micaceous sand with some trap bowlders	3–5
Slab of pegmatitic gneiss	1
Gray sandy till, with striated bowlders	½
Slab of pegmatitic gneiss	1
Gray till, rich in micaceous clay	¼–½
Slab of pegmatitic gneiss	¼–½
Gray bowlder clay	½–3
Slab of pegmatitic gneiss	½–2½
Blue-gray bowlder clay	¾
Slabs of pegmatitic gneiss and Manhattan schist	1¼
Blue-gray bowlder clay	1
Decayed schist in place with vertical foliation, intercalated with thin seams of pegmatite	6–8½

The remarkable deposit of ground moraine, which here rests upon the upturned edges of the schist, is thus found to consist largely, in the two hundred feet of section exposed along the two avenues, of a succession of huge, overlapping sheets of granitic gneiss separated by layers of sand and till or bowlder clay.

The gneiss slabs, of which a series of from four to eight are shown in any particular part of the section, consist of a rather fine-grained granitoid gneiss of constitution similar to that of the pegmatite. Their dimensions in cross-section vary from about 3 to 35 feet in length, and in thickness from 1 to 30 inches or more. There was no opportunity to determine their real shape, but apparently they consisted of flat sheets, often thinning down toward the edges to an inch or less. Some show fracture and faulting in place, as by the effect of superincumbent pressure (Fig. 5), and occasionally the extension of such a slab toward its edge into a thin pliable sheet, one or two inches thick, reveals a marked curvature as by pressure from above (Fig. 6). Toward the bottom of the section, they may be accompanied by a few small sheets of fine biotitic schist, like that of the underlying rock in place. The granitoid gneiss in these slabs shows partial to thorough decay, so that they

mark the cross-section by a series of conspicuous, white, kaolinic, lenticular bands, contrasting with the intervening layers of dark till.

FIG. 3.—Manner in which the pegmatite dike was planed off by the glacier.

The bowlder clay of these intervening layers is very dense and compact, sometimes sandy, sometimes rich in mica and clay, and contains few pebbles and occasional bowlders up to about two feet in diameter, which may show sharp, glacial striae. These consist partly of rocks of the vicinity, quartz from seams, granitoid and hornblende gneiss, etc., and partly of rocks from the Palisades on the west bank of the Hudson River, about five miles distant, viz., diabase, coarse red sandstone, indurated shale from the contact underlying the trap, etc. Nearly all these bowlders are hard and undecomposed.

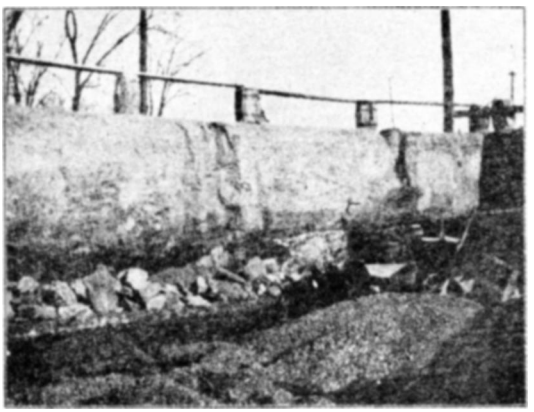

FIG. 4.—Section along Westchester Avenue.

At several points where such a trap bowlder rested immediately upon a granite slab, the latter was deeply indented, its folia separating and rising a little around the bowlder, above the upper level of the slab. Immediately

under the bowlder, the folia of the granite showed differentiation and deformation as by a crushing force from above; but the lower level of the slab rarely showed much if any depression in a direction below the bowlder (Figs. 7 and 8).

FIG. 5.—Fracture and faulting shown by one of the transported slabs.

Cause of decay.—In seeking to account for this peculiar decomposition in one tract of the schist, the action of the weather is barred out, on account of the absence of such decomposition in adjoining areas of schist, as well as in the other pegmatite dikes of the Bronx region, the absence of concentration of iron oxide from agencies of mere oxidation,[1] and the sharp line of demarkation between this tract and the unchanged schist. All the facts point to some agency which could produce deep local corrosion, and the considerable leaching shown by the removal of iron oxide and by the residues of white kaolin. The presence of the pegmatite dike across the middle of this tract, and its parallelism to the sharply

FIG. 6.—Curvature produced by pressure on a transported slab.

[1] Stremme, *Zts. f. prkt. Geol.*, XVI (1908), 128.

defined border of the decay on the east, at once suggest its possible connection in some way with this chemical action. This might be referred to an attack of the schist by the magmatic vapors, "the post-volcanic gas exhalations" of Weinschenk, accompanying the eruption of a dike of acid constitution, but for the entire absence of such effect in the vicinity of the tourmaline-bearing granite dikes which abound throughout this region. Taking all the facts here observed, we conclude that at this locality we find proofs, in the deep erosion, solution, and leaching, of the long-continued action of humus acids from peat-water, resulting in products which correspond to the "Grauerde" of Germany, studied by Ramann, Wüst, Selle, Stremme, etc.[1] It seems probable that this deep local decay of both gneissic schists and the inclosed pegmatite records the continuous corrosion of an ancient pre-glacial peat-bog. The eastern border of the bog appears to be marked by the sharply defined eastern limit of this decayed tract. The wall of impervious pegmatite may perhaps have formed a dam to confine the corrosive liquids, as in a vat, along this edge of the ancient bog; in such case the limit of corrosion would naturally lie parallel to the line of the dam.

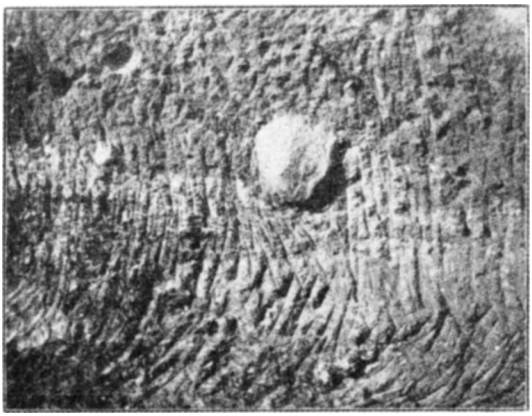

FIG. 7.—Showing how a bowlder was forced into one of the transported slabs.

With the prevalent tendency to attribute the formation of the original layer of laterite over the northern part of our continent mainly or exclusively to weathering by meteoric agencies, there seems to have been little recognition of the view above suggested in explanation of the local instances of deeper decomposition of

[1] H. Rösler, *Zts. f. prkt. Geol.*, XVI (1908), 251–54.

crystalline rocks which have escaped the glacial scouring. It therefore may be added that we find abundant evidence of the wide distribution of tundra and peat-bogs all over this region, for a long period before the advance of the continental glacier as well as since its retreat. In the adjoining region, Westchester County, Mather recorded, sixty years ago, observations on peat-bogs, covering in the aggregate nearly 400 acres. Throughout the Bronx tract, in all directions around the locality we have described, we have noted many remnants of these, in street and house excavations, which have not yet been destroyed by the advances of the great city. These now vary widely in area and in depth. A few instances will be presented to show that this form of chemical corrosion must have been here an active factor in degrading even the elevations of the rock-surface.

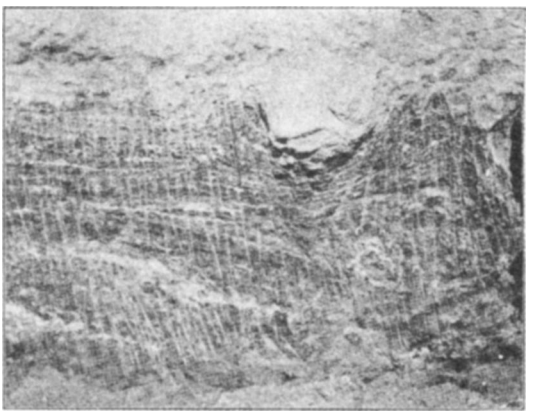

FIG. 8.—Another bowlder that was forced into a slab.

Thus, along the low valley now occupied by Morris Avenue, the depression in the glaciated surface was formerly filled with peat, even now particularly well shown in the vicinity of 170th Street. In filling in this street with rock, the peat was forced up in places to a height of ten feet on each side, and its surface cracked in all directions, revealing pockets of fresh-water shells. Thence the bog certainly stretched for a quarter of a mile, with a width of several hundred feet; while there is evidence of its former extension southward, probably as far as the Harlem River, and northward for an indeterminate, but long, distance. At 178th Street and Honeywell Avenue, a peat-bog yet remains and has recently been partially excavated, of which the original area, we estimate, must have occupied several hundred acres along the low valley. Its depth, as

proved by driven piles, reached, here, twenty-two feet. The bed of this formerly great swamp is now crossed by Daly Avenue, Honeywell Avenue, Southern Boulevard, Mapes Avenue, and Prospect Avenue. At Daly Avenue near Tremont Avenue, the depth of the peat was such that it was found necessary for foundations to drive piles forty-five feet in length. Not only were the lower grounds so filled up, especially the long valley depressions, such as those of the Bronx River, Eastchester Creek, Tibbit's Creek, etc., but thin local sheets seem to have rested in the hollows among the rounded hummocks of the glaciated upland; these are in part still represented by little marshes, or the ponds in the various parks. It appears but a moderate estimate to assert that at least one-third of the surface of this region was once covered by an almost continuous sheet of fresh-water bog, out of which the higher elevations protruded as knobs of forest-covered rock. Along the adjoining coast at Hunt's Point, Bartow, etc., these ancient bogs have been since overlaid, during the subsidence now in progress, by a sheet of salt meadow, surrounding a large number of small scattered islets of now bare outcrops of gneiss and granite.

Further evidence of the early and long activity of organic acids in solution, removal, concentration, and deposit of iron oxide from the surface of these rocks is afforded by numerous accumulations of bog iron ore once found throughout this region as well as over Manhattan Island. Though generally small, some of these were of sufficient volume to be of economic importance and use two hundred years ago.

Escape of decayed schist from removal by the glacier.—There was here no knob or eminence on the northwest for the protection of the softened schists from the scour of the ice moving from that direction. On the contrary, a low valley lies on that side, which we presume was occupied by the peat-bog. The pegmatite itself, though softened, probably served long as the main protection of the schist, in connection with the pegmatitic branches and seams intercalated in the schist in this part of the tract. The next resulting condition was apparently the erosion of this surface of the schist in an inclined plane, tending to lift the edge of the ice-sheet

up to the surface of the solid rock. The last phase appears to have been the plucking-up of huge thin slabs from a mass of thinly foliated granite, somewhere in the valley adjoining on the west, and their deposit as a ground-moraine over this inclined plane, with intervening sheets of bowlder clay, in a kind of natural masonry, for further protection of the underlying soft schists.

Evidences and measure of the superincumbent pressure.—Soft as this granite is now found, it is obvious that it must have possessed much strength and rigidity at the time of its transport by the ice in the form of slabs, mostly from a few inches up to a foot in thickness, although commonly ten to twenty feet or more in greatest extension. The pressure upon them, as well as their rigidity, is shown by the frequent fractures and faulting, and the bending of thin edges. Still more significant is the crushing of the rock within the slabs at the contact with overlying bowlders of trap, which have been pressed down into pockets in the granite. In one case (Fig. 7) the bowlder appears to have been lifted subsequently somewhat out of its pit and the clay forced in beneath it. In another (Fig. 8) the crushed granite rises around the imbedded bowlder, which was eighteen inches in diameter, as if the rock was almost plastic, either on account of the great pressure or of its own softened condition, or both. We had almost hoped to have found here a natural record of the weight of the superincumbent ice, and therefore of its thickness, by estimating the volume of the granite crushed beneath the imbedded portion of the bowlder. This was found impracticable, from the impossibility of determining the crushing strength of the rock at the time of its penetration. However, we already possess some measure of the thickness of the ice-sheet in this region in the presence of glacial striae, often an inch in depth, at points 250 to 300 feet in elevation; e.g., on the edges of the gneiss over the summit of Inwood Heights, Manhattan Island, and on the trap along the edge of the Palisade escarpment, on the west side of the Hudson River. These imply a pressure which could hardly have been exerted by a sheet of ice less than 1,000 feet in thickness.